

GALAPAGOS ISLANDS ECUADOR UPPER AIR STATION



Upper Air Observatory Building

REPORT

FOR PROJECT SURVEY AND INITIAL WORK

METEOROLOGICAL SERVICE OF NEW ZEALAND LIMITED

4 August 2003

TABLE OF CONTENTS

1	SUMMARY	4
2	BACKGROUND	4
2.1	Overview.....	4
2.2	Objectives	4
2.2.1	Hydrogen facility.....	4
2.2.2	Digicora ground station and communications equipment	5
2.2.3	Training	5
2.2.4	Proposal	5
3	FINDINGS.....	6
3.1	Station information.....	6
3.1.1	Location.....	6
3.1.2	Station staff	6
3.1.3	Contact information	6
3.2	Present observing program:.....	6
3.2.1	Upper wind measurement only:.....	6
3.2.2	Upper wind, pressure temperature, humidity measurements:.....	6
3.2.3	Surface programme	7
3.3	Present equipment and services	7
3.3.1	Ground station	7
3.3.2	Hydrogen facilities	8
3.3.3	Other equipment on station	11
4	RECOMMENDATIONS.....	12
4.1	Ground station.....	12
4.1.1	Upgrade option	12
4.1.2	Replacement options	13
4.1.3	Replacement option two	13
4.2	Hydrogen plant.....	14
4.3	Hydrogen storage tanks	14
4.3.1	Option One	14
4.3.2	Option Two.....	14
4.3.3	Mounting pad.....	15
4.3.4	Regulatory issues	15
4.4	Ancillary services	15

4.4.1 Power supply 15

4.4.2 Water supply 15

4.5 Building 15

5 IMPLEMENTATION 16

5.1 Timelines 16

5.2 Implementation table 17

6 PRICING..... 17

6.1 Work initiation and payment..... 18

6.2 Notes 18

7 POINT OF CONTACT 18

8 ACKNOWLEDGMENTS 18

1 Summary

The Galapagos site survey has been completed and we are pleased to provide our report and recommendations on what is needed to restore the station at San Cristobal within the GCOS GUAN programme. We were surprised to learn that the station was already providing three radiosonde soundings per week for a water vapour and ozone sampling programme. Our findings revealed that with the provision of upper air consumables, the recommended replacement of the hydrogen generator and tank and some upgrade of related ancillary services, the upper air station should function well in the immediate term. From about 2005, San Cristobal, along with many other upper air stations that use older Vaisala equipment, will need to consider the best options for upper air measurement following the introduction of the RS92 radiosonde. Some commentary is provided on that issue in this report together with an implementation proposal as referred to in the site survey work prescription.

2 Background

2.1 Overview

WMO GCOS Secretariat commissioned MetService to undertake a survey visit to determine the present condition of the upper air facility at San Cristobal, Galapagos Islands in order to identify the extent of assistance needed for restoration of the upper air programme.

This visit was carried out between 30 June and 3 July 2003 by Mr Bill Witham, a senior engineer with MetService and who has had extensive experience with upper air equipment in New Zealand and at Pacific Island stations. With recent experience and training in the comparatively new Proton Hogen hydrogen systems he was well suited to evaluate the requirements at San Cristobal for a new plant to be installed.

2.2 Objectives

The programme of work for this visit was:

2.2.1 Hydrogen facility

Review the existing hydrogen facility, identify changes necessary to accommodate a Proton Energies hydrogen generator. These are to include:

- Determine generator site
- Determine any necessary building modifications
- Identify services requirements (electricity, water, drainage)
- Resolve gas storage tanks (use of any existing tanks or replace; if replace – recommendation whether to provide or source locally)
- Determine gas plumbing requirements

- Resolve transitional arrangements to minimise disruptions to any existing programme
- Discuss all aspects of this work with appropriate Instituto Nacional de Meteorología e Hidrología counterparts and obtain their agreement, or modify as necessary, that the planned work complies with any electrical and hazardous goods regulations.
- Resolve and clearly identify to Instituto Nacional de Meteorología e Hidrología staff the pre-installation site work that will be required prior to the installation visit.
- Establish (if possible during the visit) the costs of the pre-installation site work that will be expended locally and the extent to which this is required to be a charge to the project.

2.2.2 Digicora ground station and communications equipment

- Inspect and test as far as possible the Digicora ground station, the data collection platform, and the transmitting system and antenna
- Identify as far as possible any faults and parts required for repair.
- Effect any repairs that are possible if time permits provided all other work has been completed
- If more extensive workshop testing is required to identify faults than is possible with the facilities available or within the time allowed then discuss with the Instituto Nacional de Meteorología e Hidrología counterpart alternative options.

2.2.3 Training

- Discuss and resolve training requirements with Instituto Nacional de Meteorología e Hidrología counterpart (this is to encompass technical training on all upper air equipment as required)
- Identify resources needed to provide this skills transfer.

2.2.4 Proposal

- Prepare and submit a detailed proposal to WMO GCOS Secretariat for funding consideration to:
 - Install and commission a Proton Energies hydrogen generator that will be procured by WMO and shipped directly to the site.
 - Procure, ship and install any additional ancillary equipment that is required, or that will promote the operational sustainability of the system and that MetService has used on its installation.
 - Undertake the work that is required to be completed at the site before installation (it is intended that this would be completed or arranged for by the Instituto Nacional de Meteorología e Hidrología)
 - Repair and re-commission all upper air ground equipment as necessary including the Digicora ground station, Data Collection Platform, satellite transmitter and antenna.

- Provide training as identified
- The proposal shall include reporting on the findings of the survey visit.

3 Findings

3.1 Station information

3.1.1 Location

The station, operated by the Instituto Nacional de Meteorologia E Hidrologia (INAMHI) is located on several hectares of land adjacent to San Cristobal airport.

3.1.2 Station staff

Officer in Charge: Senor Mario Agama Reys
Staff: Senor Jamie E. Corneso Poveda, and
Senor Jimmy Francisco Paredes Mora.

3.1.3 Contact information

Telephone/facsimile: +593 5 520340
Email- galapago@inamhi.gov.ec

3.2 Present observing program:

The upper air programme presently comprises:

3.2.1 Upper wind measurement only:

A daily pilot balloon flight is completed using a theodolite and visual tracking until the balloon becomes unsighted due to cloud or range.

3.2.2 Upper wind, pressure temperature, humidity measurements:

Three soundings per week are completed using PTU/GPS radiosondes, and one sounding per week is completed using PTU radiosondes plus ozone and water vapour sampling.

The radiosondes are presently the Vaisala RS80 model and, together with the associated balloons, are supplied by the University of Colorado under the Sounding of Ozone and Water Vapour in Equatorial Region program (SOWER).

The SOWER programme contact is: Holger Voemel.
Telephone: +1 303 497 6192.

As these present radiosonde flights are for the SOWER programme they are required to be commenced within 30 minutes of satellite "AQUA" passing overhead. This is usually at about 1330 hours local time. The result is an upper air observation but not at times that are standard for GUAN.

The satellite DCP is not used as it has been superceded by email. This seems to work satisfactorily and, regardless, the allotted DCP time slot (1311 UTC) is impractical for the present programme timing requirements.

All sounding data is captured on a PC, and sent by Email to:

"Nishi Noriyuki" <nishi@kugi.kyoto-u.ac.jp>;
"Departamento de Sinóptica" <sinoptic@inamhi.gov.ec>;
<povedal@inamhi.gov.ec>;
<fegarcia@inamhi.gov.ec>;
<Holger.Voemel@noaa.gov>;
"Fumio Hasebe" <f-hasebe@ees.hokudai.ac.jp>

3.2.3 Surface programme

The station also completes three hourly synoptic observations between 0600 and 1800 hours local time.

3.3 Present equipment and services

3.3.1 Ground station

The ground station is a Vaisala Digicora MW11 (Mk 1), with a GPS option. The software revision is REV MW11.8308, which is the latest available for this configuration. This system is the same as that used by MetService at its stations.



Vaisala Digicora Ground Station

The system is fitted with a Synergetic satellite DCP that isn't functioning. As previously reported, as the DCP is superfluous no faultfinding or repair was attempted.

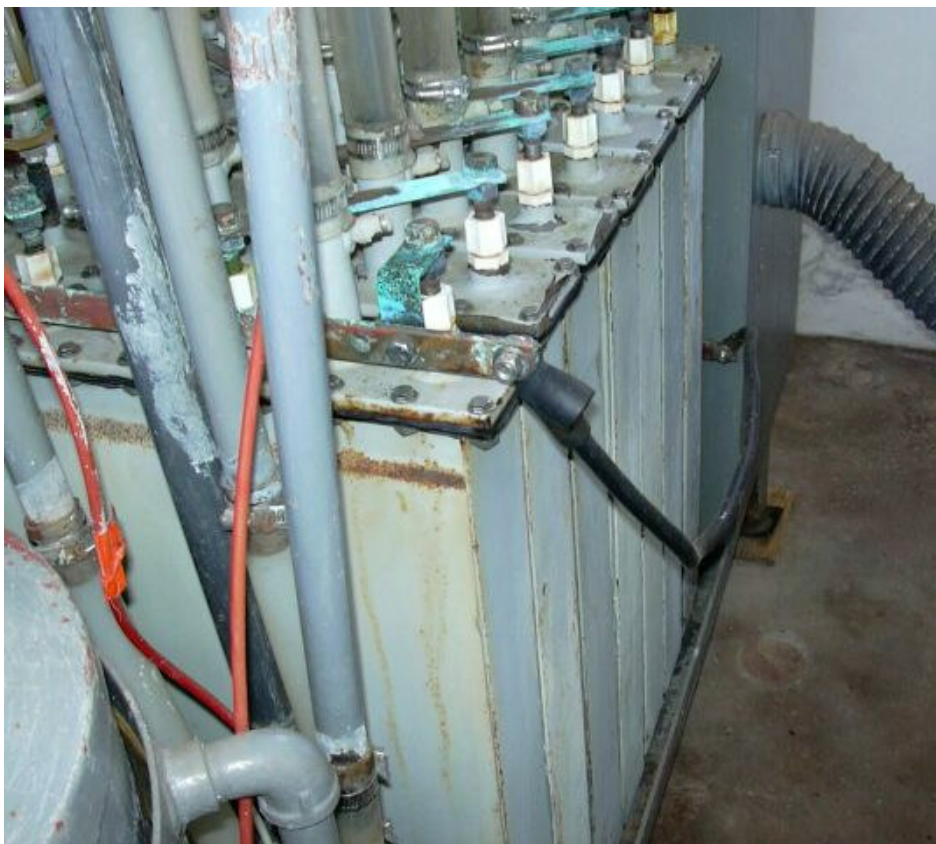
A combination of a Vaisala Digicora system and a separate ozone receiver and processor (owned by NOAA) are used for ozone soundings.

3.3.2 Hydrogen facilities

3.3.2.1 Plant

The hydrogen plant is a Stuart Electrolyser Corporation M28 hydrogen generator, Serial Nr 1377. It is 23 years old – a few years younger than some of the Pacific units.

It is installed in a 2 by 3.65 metre alcove adjacent to the balloon filling room and is in working order, with little sign of corrosion. One cell was unserviceable and was strapped out. The cells, which according to the manufacturer have a life expectancy of 10 years, were last replaced in 1995. No spares of any kind were held.



M28 Hydrogen Generator cells



M28 Hydrogen Generator compressor motor

3.3.2.2 Power supply

The M28 system has a rated power supply of single phase, 60 Hz, 220Vac. The actual power to the M28 is two phase of a three phase system, 110Vac. This provides 175Vac (measured) at the hydrogen generator during operation which could be having a detrimental effect on the Stuart equipment.

We noted that three phase is available in the township about 500 metres away but only two phase has been reticulated to the meteorological station.

Electrical reticulation seemed basic, with mains distribution boards mounted on the outside walls of buildings, without weather protection. This seemed to be standard for San Cristobal and not unique to the meteorological station. Cables between buildings lay on the surface (volcanic scree and rock), and were frequently driven over by vehicles. The station has a powerhouse, with diesel generators, but this has not been used since the town electricity supply became available 24 hours. The generators were incomplete.

3.3.2.3 Water supply

The present arrangements appear rather complicated. The artesian town supply, when available, is used to fill an in ground storage tank. When water is required on station, a pump is turned on, which feeds a garden hose. For the electrolyser, this hose is then connected to an "Aqua-Clear water purifier and pump. From there, the water is fed through another garden hose to a demineralising cartridge system and into plastic containers which provide a

storage capacity for about one month's usage. The M28 water tank is then manually topped up as required.

3.3.2.4 Hydrogen storage tank

This is a standard “Stuart” tank, providing approximately two cubic metres water capacity, or 11 cubic metres of hydrogen @ 80 psi. It is located in the open outside of the filling room, on a concrete slab. Apart from two rusted feet, possibly a result of being submerged in water caused by surface flooding during heavy rainfall, it is in good condition externally. It appears well maintained and is regularly painted.

However it was manufactured in 1980, and we understand there is no record of any testing or inspection since then. Under Australasian regulations the normal inspection for this size of tank would be yearly visual, five yearly ultrasonic and ten yearly pressure testing. Pressure relief valves would be tested and certified every five years. This work would need to be carried out by suitably qualified personnel. We were unclear whether Ecuador had similar requirements.



Hydrogen storage tank (1980 installation)

3.3.2.5 Hydrogen requirements

The present requirement for hydrogen gas is for approximately 1.5 cubic metres for 350 gram balloons (three per week) and 3.5 cubic metres for 1200 gram ozone sonde balloons (one per week). This, therefore is a total weekly requirement of eight cubic metres, or 290 cubic feet. On some occasions, 3000 gram balloons are used for ozone soundings, increasing the requirement by six cubic metres, or 220 cubic feet per week.

3.3.2.6 Balloon filling facility

The balloon filling room is measures approximately 3.65 metres by 3.65 metres by three metres high. It is fitted with bi-fold wooden doors at the front. The rear doors have been removed and opening filled with a concrete block wall. A balloon filling table with automatic fill sensor shut off (electrical) is in use. The room is well ventilated, and fitted with approved EXD light fittings. Some standard light fittings, that under Australasian hazardous goods regulations would be non –compliant, were also present but not in use. This room is used for filling 350 gram balloons, but is not large enough for the 1200 gram or larger ozone sounding balloons. These are filled out in the open, using a collapsible windbreak screen.



Balloon filling facility

3.3.3 Other equipment on station

San Cristobal has an automatic weather station, and a Profiler Radar, owned by the NOAA Aeronomy Laboratory. Manual observing instruments include

a Kew pattern station barometer, and standard temperature and relative humidity instruments. There is also an ozone receiver and processor that is owned by NOAA.

NOAA has installed a four-kilowatt Power Conversion Centre. This includes a large backup battery bank, which supplies all equipment in the office building, including the Digicora ground station. This ensures a consistent stable power supply and considerable reserves during any mains power outages.



Power Conversion Centre

4 Recommendations

4.1 Ground station

We do not foresee any immediate issues with continuing to use the Vaisala Digicora MW11 (Mk 1) ground station. It is presently operating satisfactorily. However, the MW11 is aligned to the analogue RS80 radiosondes, the availability of which is scheduled to end in 2005. Vaisala plan to replace these with the digital RS92 radiosonde. When this occurs a decision will need to be made whether to upgrade the MW11, replace it with a Digicora MW21 (Mk III) ground station or change to a non-Vaisala system.

We suggest a cost-benefit analysis be done closer to that time to determine the preferred option. We offer the following “current” information and also recommend that the following factors be taken into account.

4.1.1 Upgrade option

It should be noted that the Digicora MW11 was designed in 1987, and was replaced by the MW15 in 1994. Vaisala policy is to support equipment for at least ten years from end of production, but from experience parts for the

MW11 are now getting difficult to obtain, and this support cannot be guaranteed.

The following components would require replacing:

- UPP210A - Receiver Processor Card
- GC25 - Baseline Check set
- Card Frame modification kit (Backplane wiring changes required)
- New set of software/firmware

We suggest budgeting USD \$20,000 per system (which would include the upgrade kit and instructions, and labour).

4.1.2 Replacement options

The upgrade of the MW11 option still leaves stations with an old system with the probability of increasing outages as parts fail and decreasing capability to source failed components. An upgrade option would seem incompatible with the intent of the GCOS GUAN restoration work to provide greater integrity in the upper air observing network. However, we are mindful of the cost considerations.

Option One:

Replace the MW11 Digicora with the latest MW21 Digicora. Estimated price USD120,000

Option Two:

Option One plus add a Vaisala radiotheodolite to the system. This would also allow lower cost PTU radiosondes to be used, with considerable consumables savings. (about half the price of a GPS radiosonde?) Estimated capital cost USD 155,000

On days when strong winds aloft could be experienced resulting in low elevations and consequent signal losses with the radiotheodolite system then a GPS radiosonde would be used. (We note that the equatorial location of San Cristobal makes that quite improbable).

On all other days the radiotheodolite is used for wind finding utilising the cheaper PTU radiosonde.

4.1.3 Replacement option two

Consideration should be given to abandoning the Vaisala system and changing to an alternative upper air system and supplier, perhaps using radiotheodolite plus PTU radiosonde system. We do not have cost information to know if this is an attractive option from a financial perspective. We believe that an equatorial station such as San Cristobal would be the least affected by signal losses resulting from low elevations that affect radiotheodolite measurements.

However, in light of the project intent, we suggest a significant consideration would be the reliability, robustness and integrity of any new and unproven system.

4.2 Hydrogen plant

The present Stuart Electrolyser Corporation M28 hydrogen generator has reached the end of its economic and practical life, with frequent extended outages due to lack of spare components. Many parts are no longer available from the manufacturer, and it is only with the assistance of NOAA that the system has been kept going. Under the GUAN restoration project the demands on the M28 will increase considerably and it is important that a plant is in place that can meet these requirements and not be subject to outages. It is therefore recommended that it be replaced.

A suitable replacement, using modern technology is the Proton Hogen 20 that is manufactured by Proton Energy systems.

We understand that the GCOS GUAN restoration project will directly procure and arrange delivery of the Proton Hogen system to San Cristobal. It is important that the unit to be supplied contains the modifications for a tropical environment that resulted from the work MetService completed with Proton Energy Systems. A full spares package is also recommended.

We note that there may be a four month lead time on supply ex factory.

4.3 Hydrogen storage tanks

As the present hydrogen storage tank has not been tested since manufacture, its continued use is not recommended. We see two options for replacement.

4.3.1 Option One

We understand that some Proton systems have been supplied with stainless steel tanks complete with associated manifolds and plumbing. We believe that the price is of the order of USD 20,000 excluding freight.

4.3.2 Option Two

MetService has used galvanised steel tanks complete with associated manifolds and plumbing with its Proton installations. These have been especially designed and approved under the latest Australasian regulations. Three or four 250 litre tanks are used enabling a tank to be withdrawn for testing without disrupting the programme. The tank design and size has enabled the tank testing to only be required every ten years. The estimated cost for this option (four tanks), ex MetService, would be about USD 12,000 including freight. Assumes no import levies or taxes.

4.3.3 Mounting pad

We recommend that a new concrete foundation be provided to mount the tank storage structure on to ensure the tanks are not immersed in any surface flood water. This would need to be locally completed and we have estimated the cost at USD 500.

4.3.4 Regulatory issues

We do not know if the American or Australasian regulations are acceptable to Ecuador or what regulatory issues may arise from any supply outside of Ecuador. We suggest that any supply under either option be clarified for acceptability with Ecuador beforehand.

4.4 Ancillary services

4.4.1 Power supply

The mains supply voltage available (effectively 175V after cable losses) is not adequate for modern equipment. A voltage step up transformer should be provided in the generator room. The estimated cost for this is USD 2000 (includes freight).

Although it was not possible to determine the regulatory requirements in Ecuador, we recommend, as a minimum, that the switchboard and meters be replaced and housed in a weatherproof box. We also recommend that the cable to the hydrogen generator room is replaced and buried underground in protective conduit, with isolating switches installed in the generator room. We estimate the local costs for this work USD 1500.

4.4.2 Water supply

Water purity is vital to the performance and longevity of the Proton Hogen 20 system. MetService uses an Aqua Solutions system and could procure that and arrange freighting to San Cristobal if required. We would estimate a price of USD 6,500 delivered, excluding any import duties and taxes that we would assume to be zero-rated.

A permanent water feed to the water purification system is also required – This would be locally provided and we have estimated the cost to be USD750.

4.5 Building

The hydrogen facility building is generally in good condition but we would recommend that some minor restoration work be completed on the filling room doors. This would involve painting and replacement of hinges. We have estimated a cost of USD 500. For electrical safety, the generation area should

be partitioned off from the balloon filling room, and a self-closing door fitted. We have estimated a cost of USD 1000.



Balloon Filling Room

5 Implementation

5.1 Timelines

The timeline is likely to be determined by the delivery date of the Proton Hogen generator. This could be four months from receipt of order, and we have used this as the timeline basis in the Implementation table below. If this is ordered now it may be possible to effect programme implementation for 1 January 2004.

MetService would be pleased to offer its engineering services, if desired by the GCOS secretariat, to effect the installation, commissioning and training in the Proton system. We would also offer procurement and supply of the water purification system, gas plumbing and tanks and transformer.

This is summarised as:

- Install and commission a Proton Energies hydrogen generator that will be procured by WMO and shipped directly to the site.
- Procure, ship and install any additional ancillary equipment that is required, or that will promote the operational sustainability of the system and that MetService has used on its installation as identified.
- Coordinate and arrange with San Cristobal/INAMI staff for the required pre-installation work to be completed. Provide training (in English) on the

new system to meteorological staff at San Cristobal and also an INAMHI engineer responsible for technically maintaining the system.

- Provide training as identified

We have evaluated the work and believe that 9 working days on station would be required to complete the work (including the de-commissioning of the M28).

5.2 Implementation table

Activity	Timeline	Cost USD
Order Proton Hogen 20 with spares kit	Asap	GCOS
Order radiosondes	Asap	GCOS
Confirm no duties or taxes payable on goods to be provided	Asap	NA
Resolve any Ecuadorian regulatory issues		NA
Decide on gas tanks options	Asap, after previous entry	20,000 ** or 12,000
Order Aqua Solutions kit	1 October	6,500
INAMHI to arrange for local electrical, water, concrete, refurbishment work	Completed pre installation	3,750
Procure voltage step up transformer	1 October	2,000
Confirmation of receipt of all shipped items by INAMHI San Cristobal	Asap	NA
Pre-installation work, Installation, commissioning, training (MetService option costed)	Asap after previous entry	21,400
Availability of INAMI engineering staff at San Cristobal for training (if travel costs for INAMHI staff required)	To coincide with implementation	1,000
Report to WMO GCOS Secretariat	Within one month of completion	NA

** Excludes freight.

6 Pricing

Price	USD
<i>Procurement- Aqua Solutions kit, gas tanks (MetService tank option) and all related plumbing, manifolds and valves, transformer, co-ordinate with INAMHI to arrange/ pay for local work; (incl INAMHI staff travel costs)</i>	\$ 25,250
<i>One MetService Engineer to coordinate/complete pre-installation work, installation, commissioning and training as proposed, provide a report. MetService Project Manager to provide a report. Total project days 25. Includes expert services, airfares, disbursements (per diems at UNDP rates, surface transport costs, taxes, visas and miscellaneous costs)</i>	\$ 21,400

This price is valid until:

Friday 29 August 2003

6.1 Work initiation and payment

Work to be initiated on receipt of WMO Purchase Order. Payment on MetService invoices:

Payment One: 50% of total due 20th month following issue of Purchase Order

Payment Two: 50% of total due 20th month following completion of work.

6.2 Notes

The price does not allow for in-country personal taxes (if any). It is assumed that no taxes other than Value Added Tax or similar will apply.

7 Point of contact

The MetService point of contact for the project is:

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P.O. Box 722
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Tel (Home): + 64 4 2374-802
Fax : + 64 4 4735-231
Email : veitch@metservice.com

8 Acknowledgments

We wish to extend our sincere thanks for the willing assistance provided to MetService people by Ing. Gustavo Garcia, the Permanent Representative and all of the staff at the San Cristobal station. Our engineer was made very welcome. The help with the logistics at San Cristobal and Guayaquil was very much appreciated especially at such short notice.

We thank Instituto Nacional de Meteorologia E Hidrologia for allowing us to be involved in this evaluation.